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A HYBRID SOLAR TRACKING SYSTEM

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ABSTRACT

In this present study, the performance results of a single axis hybrid solar tracking system was analysed. From the V-I characteristics of a typical solar cell, it is evident that with increasing irradiance the peak power point shifts upwards. To extract this continuously changing peak power, the proposed model combines a mechanical tracking system and an electrical tracking system. The mechanical tracking system is based on a photodiode array (PDA) which functions as a matrix of switches. The PDA is implemented using a sphere, whose inner surface is optimised to make it function like a high precision sensor. The electrical tracking system consists of a MPPT feedback control system. The advantage of this model is that maximum power point is tracked for varying levels of irradiance.

KEYWORDS: MPPT, Sensor, PDA, Tracker, Photodiode, Matrix Switches

INTRODUCTION

The sun is one of the most important natural resources. Solar energy is clean, renewable and abundant in most part of our world and can be converted into electrical energy by means of photovoltaic (PV) systems. The greatest advantage of harnessing solar is that PV systems can be setup anywhere, unlike the other renewable energy systems. As the sun's position changes throughout the day, a PV system has to keep track of the changing trajectory in order for the system to deliver optimum output. Such a system that physically follows the sun is a mechanical tracker. On the other hand, PV systems that are stationary and force the panel to work at their rated power are electrical tracking systems. In this project, we have combined both the above mentioned systems and have obtained a system that delivers power at a higher efficiency when compared to a fixed solar panel.

PHOTODIODE ARRAYS (PDA)

Photodiodes are semiconductor light sensors that generate current when the P-N junction in the semiconductor is illuminated by light. When a photon of sufficient energy strikes the diode, it excites an electron, thereby creating a free electron and a positively charged electron hole. A photodiode array (PDA) which consist of several photodiodes that senses the light input in parallel to position it. The PDA is given a reverse bias so as to generate a detectable current. The PDs are used as digital mode generating the photocurrents. The photodiodes are used as digital switches like devices which gets activated (closed circuit) when gets illuminated by the light. The PDA is connected in the form of an array consisting of a 10x10 matrix on the lower hemisphere. PDA is given supply only for the columns in its matrix.

RESEARCH IMPLEMENTATION

A single sphere made of hard rolled steel with a diameter of 19.5 cm with 7cmx1.5cm is coated black and has a heat resistant coating to sustain the sun's heat.

The PDs are arranged along the inner surface, covering the lower half of the sphere, in a matrix format. The microcontroller used is a standard 8051 microcontroller, it has 4 ports. Each port has 8 pins and taking one entire port, say, Port 0 and two pins from Port 1 as the column and Port 2 and two pins from Port 1 as row.

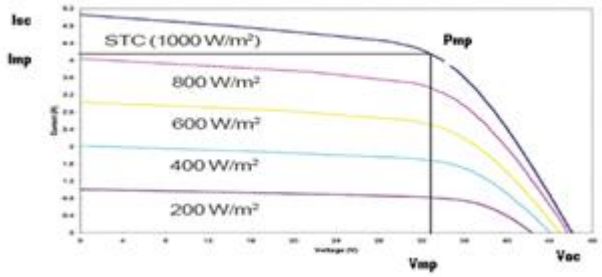

Figure 1: Shift of Peak Power Point with Increasing Irradinace

When light falls on the photodiodes which are reverse bias, it generates current which is like the operation of a closed switch, allowing the microcontroller to detect the photodiode currently illuminated. Each photodiode is attached to one column and a row. Each column is powered by the microcontroller through a resistor to reverse bias the photodiode attached to it. Each column is powered high for a few mili- seconds one after the other continuously. Hence by this principle the illuminated photodiode will be detected by the same micro controller which already knows the powering cycle of the column. The detection of the illuminated photodiode will be detected by the intersection of the powered column and the row that conducts current to the microcontroller. This process is called the matrix scanning, which detects the illuminated photodiode in the entire 10x10 matrix and fed to the microcontroller for further calculation.

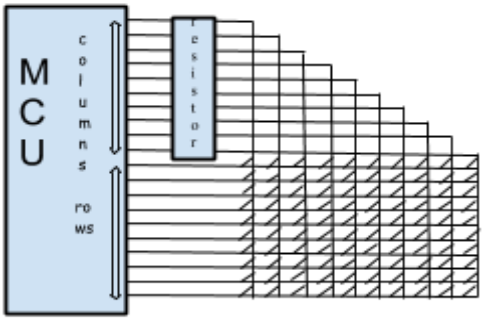

Figure 2: Implementation of the Photodiode Array

Once the microcontroller detects the illuminated PDs, the panel is turned so that it now faces the sun. However, in spite of this, the panel won't deliver its rated power. In order to ensure that the panel is delivering its rated power, the MPPT system will turn on and extract the maximum power from the panel.

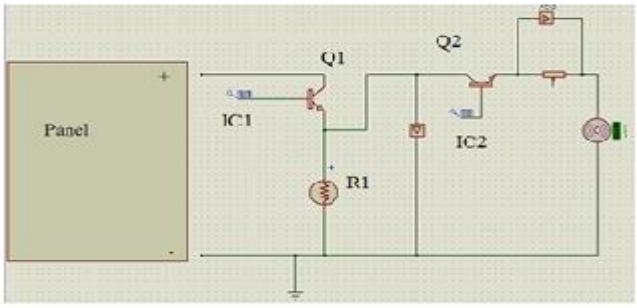

Figure 3: The Circuit for the MPPT System

SIMULATION

The photodiodes are arranged on the lower hemisphere symmetrically. Therefore only one portion of the array receives light at a time and hence, the microcontroller can differentiate morning and evening by identifying on the section of the photodiodes currently illuminated.

As the sphere is kept in the open under the sun, it must be protected from natural elements like dust, wind and rain. Therefore, it is made up of hard steel. The rectangle- shaped slit is made up of glass (transparent) for the sunlight to pass through it. The slit needs to be periodically cleaned for removal of dust on its surface. The sphere has no opening on its surface and hence water cannot enter into the sphere.

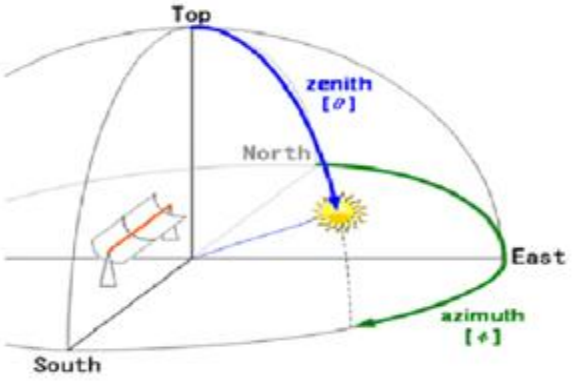

Figure 4: Various Angles of the Panel w.r.t the Sun

Table 1: Results Obtained from the Photodiode

		Voltage(Mv)	Current(Ua)
Inside the sphere- under illumination	OPEN CIRCUIT	500-750	50
	SERIES	1000-1500	50
	PARALLEL	700-750	Corresponding to input impedance
Inside the sphere-no illumination	OPEN CIRCUIT	150-250	11-15
	SERIES	1000-1500	50
	PARALLEL	700-750	Corresponding to input impedance

CONCLUSIONS

The single axis tracker is approximately 30% more efficient than the static photovoltaic panel. Another key point with regards to this system is that it extracts maximum power from the panel irrespective of the time of the day.

The main disadvantage of the single axis tracker is that it doesn't track the change in azimuth angle which is variable every month. In this model, the azimuth angle is hard-coded into the microcontroller.

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